Screening for Export Potential Potato Varieties in Bangladesh

ABSTRACT

Aims: The main aim of this study was to find out the suitable variety having the export potentiality.
Study Design: The experiment was laid out in a randomized complete block (RCB) design with the two replications in each location.
Place of the Study: The study was conducted in ten different agroecological environments across the country, namely Bogura, Jashore, Munshiganj, Gazipur, Patuakhali, Faridpur, Debiganj, Madaripur, Thakurgaon and Rangpur district of Bangladesh during November 2020 to March 2021.
Methodology: Sixty-two released potato varieties and exotic materials were used as planting materials for the experiment. Whole seed tubers of 28–40 mm were planted in the last week of November with a spacing of 60 cm between the rows and 20 cm between the plants. The crops were harvested at full maturity during March. Tuber yield was determined by adding the weights of marketable and unmarketable tubers from the net plot area and converting them to tons per hectare. After that, the tubers were graded in different grades and the dry matter of the potato was analyzed.
Results: Considering the results, the location Rangpur, Thakurgaon, Debiganj and Bogura are the most suitable place for export variety cultivation in Bangladesh. The potato variety and genotypes 13.7, BARI Alu-12, BARI Alu-61, BARI Alu-68, BARI Alu-73 and Innovator were found promising for export for their yield, tuber size and dry matter content.
Conclusion: The variety having good yield, bigger size and high dry matter could be selected for export from Bangladesh and the better-performed regions can be utilized for export quality potato production in Bangladesh.

Keywords:Potato; tuber; export, exotic materials; yield

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important commercial crops that contribute to global food security [1] due to its high yield per unit area of land. Potato is the fourth most important food crop, after rice, wheat, and maize in Bangladesh [2]. Potatoes are high in starch and low in fat and sugar. It contains vitamins including vitamin B6, niacin, folate, and vitamin C, as well as minerals like potassium, iron, phosphorus, and magnesium [3, 4]. The potato is also high in natural dietary antioxidants [5, 6], which are beneficial to humans because they protect against heart disease and lower blood cholesterol levels [7].

In 2020, China is the world's largest potato grower, followed by India, Russia, the United States, Ukraine, Germany, and Bangladesh and global potato production touched 359 million metric tons. Bangladesh ranked seventh in the world in terms of potato production [8]. In Bangladesh, the average potato yield is 20.82 t/ha, and 9.60 million tons (Mt) of potatoes were produced from 0.46 million hectares (M ha) of land [8], even though local demand for potatoes is only about 7.7 million tons (Mt). Only about a fourth of the surplus can be stored for sale. As a result, farmers' losses from unsold surplus produce and post-harvest losses are expected to be between BDT 25 to 35 billion (USD 290 to 400 million). So, the most likely solution for this surplus of potatoes is to export it to other countries or process it [9].

There is a scope for exporting potatoes in more than thirty countries, and 60 companies are engaged in the potato export business in Bangladesh [10]. More than one lakh tons of potatoes were exported in the 2014-15 fiscal year, but the figure has since fallen [10]. To enhance the export, variety selection is critical for growers who want to sell their high-quality produce [11]. Farmers require varieties that provide good yields under a variety of environmental circumstances as well as throughout time. Potato crops require significant financial investments in fertilizer and plant protection chemicals; thus, the predictability of genotype yields must be appropriately assured to preserve farmers' interests. Furthermore, the export potato variety has different requirements than our regular table potato variety. A high yielding potato variety with high dry matter, a size of more than 40 mm, and a shiny colour should be considered for export. The Tuber Crops Research Center (TCRC) of the Bangladesh Agricultural Research Institute (BARI) is working on developing potato varieties based on various characteristics, and the Bangladesh Agricultural Research Institute (BARI) has released 100 potato varieties to date [12]. Until now, the varieties have not been tested only for export qualities in various agroecological conditions, and it will be an intriguing project to evaluate these varieties for export qualities(high yield, high dry matter, bigger size, shiny color and disease free) which will be a game-changer in the potato export from Bangladesh. Because there is a huge scope to export potato to the neighboring countries, such as Sri Lanka, Nepal, and Bhutan as well as in the middle east from Bangladesh.In light of the foregoing, the current study aims to discover suitable potato genotypes for export to ensure the country's sustainable potato production.

2. MATERIALS AND METHODS

2.1 Experimental Site and Climatic Details

The experiment took place in ten different agro-ecological contexts across the country during the winter season of 2020-2021, including Bogura, Jashore, Munshiganj, Gazipur, Patuakhali, Faridpur, Debiganj, Madaripur, Thakurgaon, and Rangpur. Figure 1 and 2 represent the meteorological data on total rainfall and minimum and maximum temperatures for the potato growing season.

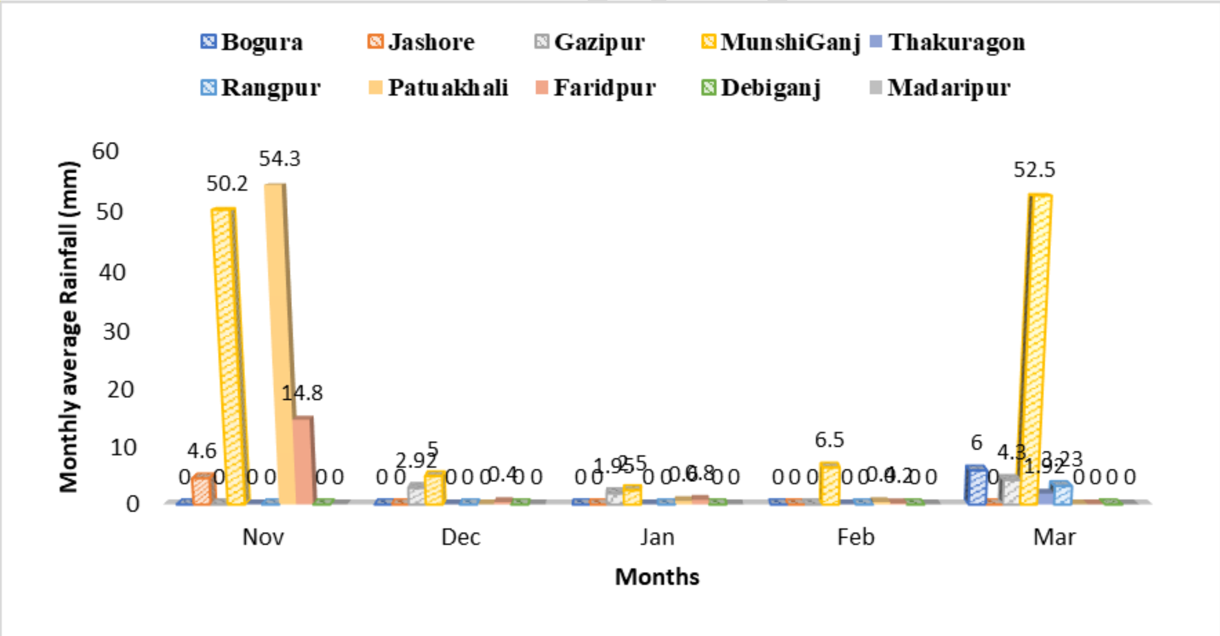

Figure 1: Monthly total rainfall (mm) of the experimental sites during the potato growing season (2020–2021).

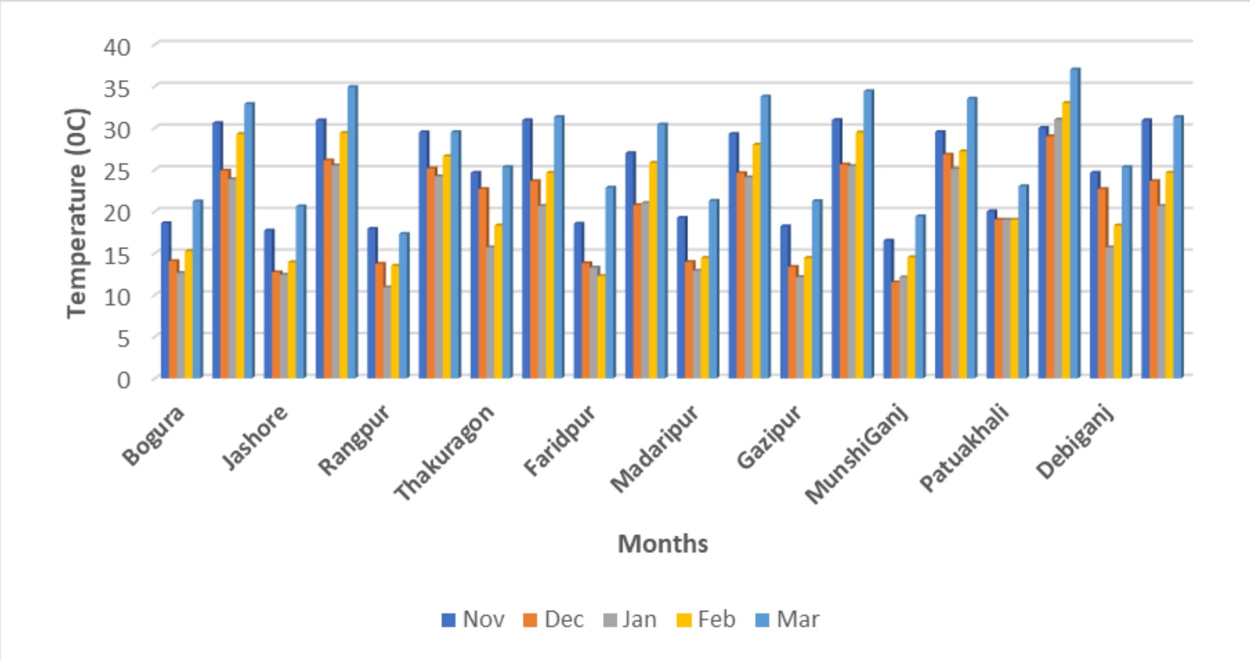

Figure 2: Monthly mean minimum and maximum temperature (^{0}C) at the experimental sites during the potato growing season (2020–2021)

2.2 Plant Materials and Experimental Design

The experimental materials comprised 62 potato varieties and exotic materials and were selected based on the availability of the seed. The experiment was set up in randomized complete block (RCB) patterns in each location and reproduced twice. Each plot was 3.9 m^2 (1.3 m x 3 m), with plant spacing of 65 cm between rows and 20 cm between plants(13).

2.3 Experimental Procedure

Well maintained and disease-free sprouted A grade (28–40 mm) whole seed tubers were planted in the last week of November. The recommended dose of manure and fertilizers were used in the form of Cow Dung, Urea, Muriate of Potash (MOP), Triple Super Phosphate (TSP), Boric Acid, Zinc Sulfate, and Gypsum [14] where half of the Urea and Muriate of Potash with a complete dose of other fertilizers were thoroughly mixed with the soil before planting. The remaining Urea and Muriate of Potash were added as a side-dressing during earthing up to 35 days after planting. Weeding, irrigation, earthing up, plant preventative measures, and other intercultural operations, were carried out according to the recommendations of the TCRC and BARI [13]. The crops were harvested when they were fully mature.

2.4 Grading of potato tubers

According to Sharkar et al. [15], after harvesting, potato tubers were divided into four grades based on their diameter in the centre. Under grade (less than 28 mm), Grade A (28-40 mm), Grade B (41-55 mm), and Over grade (more than 55 mm) were the four grades. Grade B and over size grade, which indicates potatoes larger than 40 mm, were regarded as export grade tubers.

2.5 Determination of Dry Matter Content

For tuber dry matter estimation, ten tubers from each variety's harvested potatoes were chosen at random. After that, the samples were weighted to 200 g in two subsamples, washed, chopped, and mixed, and then dried for 72 hours at 72ºC in a drying oven (Memmert GmbH, UN-260, Schwabach, Germany). Dry matter was calculated as a percentage based on the dry to fresh mass ratio [9].

2.5 Data collection and analysis

Data was gathered on a variety of variables, but only the most essential are provided in tables of results and a discussion section with adequate analysis. Data on tuber yield was obtained on a whole plot basis. Using statistical software R x 64-program version 3.3.2, the data were examined statistically, and the means were separated by LSD (least significant difference) assessed at a 5% level of probability [16].

3. RESULTS AND DISCUSSION

3.1 Average Yield Performance of the Genotypes in Multiple Environments

Due to the unique environment of each location, yields of all types varied greatly (Table 1). The initiation of tuber is triggered by short day lengths (photoperiods), and involves growth hormones. The colder the soil temperature, the more rapid the initiation of tubers and the greater the number of tubers formed. The optimum soil temperature for tuber initiation is 15 to 20˚C. Based on the climatic condition (Fig 1 & 2) and yield of potato the most appropriate area for potato production was determined to be Rangpur (average yield of 45.73 t/ha), followed by Debiganj (43.10 t/ha), Thakurgaon (41.77 t/ha), and Bogura (39.00 t/ha). While Patuakhali's environment was found to be the least productive (16.72 t/ha) for potato production. The main reason behind the low is yield is salinity and high temperature of this area. The temperature of January, February and march months were more than 30^{o}C (Fig.2). BARI Alu-72 was the genotype with the highest average yield (44.00 t/ha) and produced more than the average yield in six locations. The average yield of genotype 13.7 (42.42 t/ha) was higher than the average yield in five locations, followed by BARI Alu-12 (42.39 t/ha). The lowest yield was found in BARI Alu-58 (24.10 t/ha). These findings support Tessema et al., [17]; and Amin et al., [18], who found comparable types. These results support similar type findings of Tessema et al., [17]; and Amin et al., [18].

Table 1. Tuber Yield (t/ha) of selected potato genotypes as influenced by different environments during 2020-21

Variety\ location	Tuber Yield (t/ha)									
	Gazipur	Bogura	Rangpur	Faridpur	Munshigonj	Patuakhali	Madaripur	Thakurgaon	Debiganj	Jashore	Variety Mean
BARI Alu-7 (Diamant)	18.45	33.47	49.43	48.43	42.64	15.69	25.43	42.83	46.13	46.92	36.94c-m
BARI Alu-8 (Cardinal)	15.29	29.79	42.01	41.15	41.11	14.10	18.68	40.26	32.39	32.44	30.72p-w
BARI Alu-12 (Dheera)	24.91	38.54	58.32	40.77	54.36	20.81	33.10	43.85	62.46	46.79	42.39ab
BARI Alu-13 (Granola)	13.43	35.08	42.31	16.23	21.91	10.62	23.86	38.08	27.72	33.72	26.30wxy
BARI Alu-21 (Provento)	19.86	48.90	51.51	39.03	33.25	10.06	27.41	36.22	53.00	28.46	34.77e-r
BARI Alu-25 (Asterix)	21.11	38.26	41.98	28.45	32.18	15.97	23.48	36.67	32.92	39.62	31.06o-w
BARI Alu-27 (Espirit)	18.47	40.28	47.19	21.40	44.42	10.59	24.87	44.10	54.88	36.41	34.26f-s
BARI Alu-28 (L. Rosetta)	11.42	31.05	30.61	27.05	27.77	11.03	20.33	33.85	33.86	26.28	25.32xy
BARI Alu-29 (Courage)	17.26	29.25	30.51	17.94	27.48	11.35	45.38	29.81	32.74	20.26	26.20wxy
BARI Alu-31 (Sagitta)	10.24	38.00	37.13	21.04	36.07	-	14.85	34.81	36.72	22.18	27.89u-y
BARI Alu-32 (Quincy)	25.23	45.40	61.10	44.56	41.17	-	27.27	43.08	54.85	35.90	42.06abc
BARI Alu-34 (Laura)	12.72	34.38	41.91	28.73	30.84	-	21.81	37.05	33.53	32.82	30.42p-x
BARI Alu-35	29.32	50.57	37.40	36.57	28.90	-	34.36	34.55	36.74	32.05	35.61d-q
BARI Alu-36	21.96	37.13	48.38	42.24	29.41	17.86	25.69	26.73	43.95	40.38	33.37i-t
BARI Alu-37	22.62	33.67	44.91	36.32	33.76	22.14	26.26	33.56	34.64	34.62	32.25m-u
BARI Alu-40	26.43	44.13	54.79	35.95	26.79	21.46	36.29	49.87	51.28	36.41	38.34b-i
BARI Alu-41	31.47	44.35	38.72	50.65	38.14	13.00	36.50	45.66	46.00	45.64	39.01a-f
BARI Alu-44 (Elgar)	7.14	24.24	26.59	14.85	16.09	-	20.54	39.94	29.19	28.08	22.96y
BARI Alu-46	34.13	43.97	46.36	40.81	38.11	16.872	40.13	47.25	57.77	37.69	40.31a-d
BARI Alu-47	27.05	40.34	50.54	37.83	39.02	24.013	31.89	41.09	43.70	29.49	36.50d-n
BARI Alu-48	21.19	41.62	51.14	24.74	29.74	21.577	22.28	50.32	45.22	31.67	33.95f-s
BARI Alu-49	26.61	38.10	47.89	32.63	41.60	13.677	24.61	41.79	37.71	26.54	33.12j-u
BARI Alu-50 (7.86)	35.02	38.10	64.13	29.43	33.43	17.103	23.79	45.26	50.19	23.59	36.01d-o
BARI Alu-51 (Bellarosa)	22.79	38.54	46.04	39.93	28.25	22.115	26.95	45.26	36.82	35.77	34.25f-s
BARI Alu-52 (Labadia)	19.37	41.93	47.43	27.77	40.91	12.321	23.01	51.09	37.47	23.59	32.49l-u
BARI Alu-53 (LB-6)	27.22	35.71	53.33	37.70	39.27	20.192	26.56	43.46	43.87	33.46	36.08d-o
BARI Alu-54 (Musica)	15.10	39.46	43.14	9.18	47.62	-	15.08	37.50	38.62	20.90	26.90v-y
BARI Alu-56	26.99	36.36	53.36	31.66	33.97	17.782	19.42	36.03	40.02	31.03	32.66l-u
BARI Alu-57	19.82	41.35	49.14	26.17	32.14	22.423	25.91	45.90	41.15	31.92	33.59h-s
BARI Alu-58 (ElMundo)	-	-	18.10	-	-	10.897	27.09	40.32	-	-	24.10xy
BARI Alu-59 (Metro)	20.64	39.63	34.58	31.17	30.01	23.556	22.98	41.41	41.34	32.05	31.74n-v
BARI Alu-60 (Vivaldi)	21.42	42.37	47.54	35.52	32.40	17.808	23.96	44.04	32.18	27.95	32.52lm-u
BARI Alu-61 (Volumia)	14.78	42.23	41.71	33.39	24.57	-	21.14	37.05	45.41	28.46	29.77r-x

Variety\ location	Tuber Yield (t/ha)									
	Gazipur	Bogura	Rangpur	Faridpur	Munshigonj	Patuakhali	Madaripur	Thakurgaon	Debiganj	Jashore	Variety Mean
BARI Alu-62 (9.112)	23.64	44.20	51.51	43.94	36.19	19.679	25.11	49.29	49.08	36.15	37.88b-k
BARI Alu-63 (9.125)	30.72	36.59	45.08	44.16	46.26	10.308	24.60	47.05	43.67	35.64	36.41d-n
BARI Alu-64 (Folva)	17.50	38.44	42.78	34.43	43.42	-	20.00	37.95	36.24	32.82	33.73g-s
BARI Alu-66 (Pamela)	20.32	43.36	46.48	43.88	35.72	-	23.97	45.90	51.44	37.95	38.78a-h
BARI Alu-68 (Atlantic)	19.85	24.30	38.31	43.12	35.36	15.038	17.57	32.73	31.98	22.44	28.07u-y
BARI Alu-71 (Dolly)	22.20	26.78	34.62	35.21	35.90	-	20.51	33.27	33.85	29.49	30.20q-x
BARI Alu-72 (CIP-139)	36.77	46.83	50.39	51.33	47.78	16.692	42.77	43.01	54.90	49.49	44.00a
BARI Alu-73 (CIP-127)	29.77	33.50	45.99	34.77	30.80	21.987	24.63	36.15	51.87	35.77	34.52f-r
BARI Alu-77 (Sarpomira)	14.89	35.36	35.95	27.34	29.51	-	18.68	40.51	31.30	17.69	27.91u-y
BARI Alu-78 (CIP-112)	24.80	40.45	36.40	30.28	32.12	14.544	28.14	54.74	56.65	36.41	35.45d-q
BARI Alu-79 (CIP-126)	27.64	39.31	52.57	34.24	34.30	24.885	32.18	46.86	46.49	37.05	37.55b-l
BARI Alu-81 (CIP-10)	25.96	43.63	46.09	45.15	43.76	15.692	26.19	51.47	43.79	55.00	39.67a-e
BARI Alu-82 (11.68)	34.96	48.03	35.99	42.32	43.86	18.746	27.52	35.64	42.41	36.92	36.64d-n
BARI Alu-83 (Cimega)	21.16	34.91	59.82	22.08	50.76	-	33.31	40.26	50.85	36.41	38.84a-h
BARI Alu-84 (Memphis)	23.03	47.01	55.69	33.42	47.04	7.362	21.66	42.16	40.67	34.23	38.32b-j
BARI Alu-85 (7 four 7)	21.39	45.74	56.39	22.90	43.24	7.244	28.08	53.40	52.88	35.77	39.98a-e
BARI Alu-86 (12.13)	19.90	42.61	51.01	48.97	45.98	20.344	26.24	56.23	48.69	36.79	39.68a-e
BARI Alu-87 (CIP-225)	24.76	40.24	53.12	53.04	46.56	14.413	36.40	50.77	-	40.13	39.94a-e
BARI Alu-88 (CIP-239)	37.43	40.42	53.95	38.61	33.97	16.885	22.70	58.14	-	48.08	38.91a-g
BARI Alu-89 (Fortus)	27.94	37.60	48.09	36.64	37.33	17.500	26.55	43.46	48.68	37.56	36.14d-o
BARI Alu-90 (Alouette)	20.69	41.04	47.99	31.72	35.43	16.051	23.51	38.91	39.84	32.44	32.76k-u
BARI Alu-91 (Carolus)	15.58	32.78	32.44	27.26	33.16	-	24.59	31.90	33.81	22.56	28.23t-y
Labela	25.64	40.23	50.07	35.65	33.20	21.167	32.41	43.33	37.46	37.82	35.70d-p
Jarjina	23.12	40.33	44.49	33.35	39.49	18.487	26.94	36.41	48.32	30.13	34.11f-s
Cumbika	13.91	37.26	46.56	34.62	39.55	16.872	22.31	48.65	39.95	29.62	32.93k-u
13.7	25.52	49.78	49.26	56.97	39.57	22.705	37.37	39.68	58.22	45.13	42.42ab
Sun Red	24.81	41.93	51.36	40.03	39.34	19.282	31.06	30.71	49.12	43.85	37.15c-m
Innovator	15.86	27.63	43.54	20.36	24.60	-	25.38	39.71	43.14	22.82	29.23s-x
Alverstone Russet	19.81	42.28	50.38	44.56	29.79	11.897	28.00	42.82	42.92	39.87	35.23d-q
Location Mean	22.44	39.00	45.73	34.75	36.25	16.72	26.44	41.77	43.10	33.92	34.38
CV	17.01										

3.2 Tuber grading by weight

The tuber grade by weight is a key characteristic of a variety when determining its export and processing potential. Based on the buyer’s preference, the potato tuber grade of >40 mm is considered suitable for export from Bangladeshand the average grades of tubers by weight are presented in table 2. The bigger size of the tuber was produced in Thakurgaon (82.29%), Rangpur (82.11%), Debiganj (81.83%) and Bogura (80.51%) locations where more than 80% of the tubers were greater than 40mm in size compared to the tuber of other locations. This is due to the soil and climate conditions of the Northern districts of Bangladesh which is favorable for potato production. Tuber bulking is caused by a drop in night temperature in these places, which causes tuber cells to expand due to the accumulation of water, nutrients, and carbohydrates, resulting in a larger tuber size. The genotype sun red produced the average highest size tuber (88.34%) followed by BARI Alu-61 (87.15%), BARI Alu-73 (85.75%), Labela (85.03%), BARI Alu-79 (84.77%), BARI Alu-63 (84.75%), BARI Alu-68 (84.37%), BARI Alu-84 (83.5%) and Innovator (82.34%).

Table 2. Performance of potato varieties for tuber grading by weight (>40 mm) in different location during 2020-21

Variety\ location	Tuber Grading % by wt. (>40mm)									
	Gazipur	Bogura	Rangpur	Faridpur	Munshigonj	Patuakhali	Madaripur	Thakurgaon	Debiganj	Jashore	Mean
BARI Alu-7 (Diamant)	48.45	70.23	83.85	77.92	80.07	91.45	63.7	75.6	78.62	56.96	72.69mno
BARI Alu-8 (Cardinal)	44.18	78.24	75.98	80.24	88.11	67.27	69.98	79.53	79.67	43.1	70.63nop
BARI Alu-12 (Dheera)	56.5	75.73	79.47	72.16	75.46	75.11	76.9	74.25	81.32	40.85	70.78nop
BARI Alu-13 (Granola)	47.79	80.64	81.17	35.85	70.51	82.73	52.66	80.31	75.67	38.84	64.62pq
BARI Alu-21 (Provento)	73.62	93.64	91.76	83.45	78.52	77.71	78.03	85.48	94.53	40.02	79.68c-l
BARI Alu-25 (Asterix)	44.39	74.69	77.73	61.23	63.86	64.52	51.11	61.62	77.46	39.16	61.58qr
BARI Alu-27 (Espirit)	37.61	73.65	76.73	49.17	74.13	69.01	48.13	83.57	78.84	31.37	62.22qr
BARI Alu-28 (L. Rosetta)	-	86.3	81.19	76.52	78.08	70.81	71.99	77.69	90.43	37.1	74.46i-o
BARI Alu-29 (Courage)	61.88	85.81	89.89	82.63	77.48	88.36	52.16	87.06	93.06	44.85	76.32g-n
BARI Alu-31 (Sagitta)	77.37	83.12	93.58	86.9	72.78	92.18	83.04	85.34	89.36	59.19	82.29a-g
BARI Alu-32 (Quincy)	71.23	76.03	61.83	79.03	78.19	73.78	68.81	-	74.8	25.71	67.71opq
BARI Alu-34 (Laura)	64.73	81.48	83.46	74.61	70.04	-	66.09	78.67	75.54	37.44	70.23nop
BARI Alu-35	66.08	73.4	70.28	75.39	81.89	96.71	85.43	82.16	76.72	35.78	74.38i-o
BARI Alu-36	71.35	71.19	75.24	82.1	73.93	79.33	79.34	77.7	84.69	43.51	73.84j-o
BARI Alu-37	52.1	74.99	68.52	76.73	79.77	68.46	70.63	57.35	77.98	27.45	65.4pq
BARI Alu-40	68.76	74.28	81.19	81.84	83.99	80.58	85.35	84.83	85.62	28.6	75.5g-n
BARI Alu-41	64.56	66.68	61.21	78.65	82.23	47.93	71.19	71.16	75.31	35.89	65.48pq
BARI Alu-44 (Elgar)	52.16	60.25	63.97	46.55	71.93	60.43	45.41	76.17	79.17	11.39	56.74rs
BARI Alu-46	72.06	79.6	84.91	75.23	81.62	73.25	87.6	89.48	79.81	32.63	75.62g-n
BARI Alu-47	53.43	42.9	62.56	67.07	59.52	53.81	59.87	56.32	65.6	8.94	53s
BARI Alu-48	52.29	72.63	71.74	72.24	72.24	76.05	73.72	78.17	62.71	23.85	65.56pq
BARI Alu-49	61.84	67.94	74.48	76.94	78.9	72.86	59.62	77.51	66.25	13.04	64.94pq
BARI Alu-50 (7.86)	-	89.49	89.86	91.38	81.2	85.76	85.33	-	86.94	19.56	78.69d-m
BARI Alu-51 (Bellarosa)	76.5	86.51	90.38	90.36	81.77	75.24	76.36	88.82	81.52	29.39	77.69f-m
BARI Alu-52 (Labadia)	76.43	86.78	84.68	92.04	87.07	84.28	74.9	92.92	80.92	37.6	79.76c-l
BARI Alu-53 (LB-6)	67.45	89.27	92.64	84	78.84	75.68	86.25	-	86.14	40.76	77.89e-m
BARI Alu-54 (Musica)	-	82.12	85.03	82.24	83.68	90.72	72.44	79.93	78	33.61	76.42g-n
BARI Alu-56	83.73	79.44	83.7	84.44	85	89.19	77.17	84.64	81.05	40.75	78.91d-m
BARI Alu-57	69.91	88.5	71.36	74.37	79.33	68.9	81.36	86.39	79.55	55.07	75.47g-n
BARI Alu-58 (ElMundo)	-	-	89.9	-	-	81.53	69.18	72.29	73.45	-	77.27f-n
BARI Alu-59 (Metro)	52.78	77.76	69.05	76.22	84.86	83.9	56.32	87.26	86.05	49.89	72.41mno
BARI Alu-60 (Vivaldi)	49.9	73.97	84.72	77.1	81.31	64.08	69.74	79.49	70.28	31.78	68.24opq
BARI Alu-61 (Volumia)	90.38	95.25	90.61	90.63	88.29	79.18	86.63	89.94	84.91	75.67	87.15ab
BARI Alu-62 (9.112)	56.45	79.5	80.86	81.64	77.48	69.25	79.52	86.18	74.52	37.61	72.3mno

Variety\ location	Tuber Grading % by wt. (>40mm)									
	Gazipur	Bogura	Rangpur	Faridpur	Munshigonj	Patuakhali	Madaripur	Thakurgaon	Debiganj	Jashore	Mean
BARI Alu-63 (9.125)	82.24	85.06	92.5	92.72	91.52	79.61	85.86	88.97	92.63	56.39	84.75a-e
BARI Alu-64 (Folva)	68.66	94.36	86.43	89.49	82.78	73.99	69.89	90.07	88.06	39.26	78.3d-m
BARI Alu-66 (Pamela)	84.83	86.53	88.33	85.95	82.11	75.54	81.83	89.31	82.45	59.74	81.66a-h
BARI Alu-68 (Atlantic)	77.5	86.68	91.08	88.81	87.39	87.9	91.04	91.86	93.96	47.48	84.37a-f
BARI Alu-71 (Dolly)	70.17	69.88	82.39	84.5	81.64	76.05	88.97	58	81.75	39.26	73.26l-o
BARI Alu-72 (CIP-139)	75.71	81.82	76.38	82.82	84.44	77.8	83.96	84.84	93.49	42.89	78.42d-m
BARI Alu-73 (CIP-127)	90.34	92.65	92.31	80.81	75.14	95.56	87.36	92.24	88	63.1	85.75abc
BARI Alu-77 (Sarpomira)	56.37	84.06	83.26	57.22	75.94	73.25	66.89	85.47	72.1	38.16	69.27nop
BARI Alu-78 (CIP-112)	54.52	65.43	61.25	66.53	80.16	52.66	71.01	78.71	70.12	22.49	62.29qr
BARI Alu-79 (CIP-126)	85.04	86.67	95.17	83.03	88.19	91.19	81.55	90.75	92.8	53.28	84.77a-e
BARI Alu-81 (CIP-10)	80.66	85.07	84.75	87.21	83.04	73.7	81.68	82.13	89.3	61.99	80.95b-i
BARI Alu-82 (11.68)	73.15	86.61	79.99	79.77	82.93	78.05	82.56	81.38	75.98	39.93	76.04g-n
BARI Alu-83 (Cimega)	65.46	81.21	85.29	71.95	86.78	94.46	64.63	79.99	66.12	42.68	73.86j-o
BARI Alu-84 (Memphis)	80.82	87.63	92.23	91.75	87.44	87.29	82.84	86.65	92.78	45.56	83.5a-f
BARI Alu-85 (7 four 7)	75.64	89.15	91.29	84.65	83.74	67.97	65.59	90.68	90.94	42.82	78.25d-m
BARI Alu-86 (12.13)	44.85	74.14	84.84	79.99	85	84.23	66.57	88.23	87.94	40.8	73.66k-o
BARI Alu-87 (CIP-225)	60.91	61.4	54.34	71.2	64.05	68.21	74.62	68.5	-	36.65	62.21qr
BARI Alu-88 (CIP-239)	66.51	86.39	90.56	88.76	76.94	63.78	83.95	90.39	-	52.5	77.75f-m
BARI Alu-89 (Fortus)	72.73	82.73	87.26	78.85	80.15	88.71	88.26	89.31	79.79	30.37	77.82f-m
BARI Alu-90 (Alouette)	64.82	85.95	85	81.09	82.75	88.82	70.16	82	73.76	39.08	75.34h-n
BARI Alu-91 (Carolus)	45.75	78.11	80.84	77.81	83.28	85.03	66.52	85.23	87.05	38.76	72.84mno
Labela	-	88.98	93.5	92.76	91.55	91.46	82.14	92.41	93.75	38.73	85.03a-d
Jarjina	72.76	85.54	90.47	78.88	84.2	77.33	73.9	82.91	82.15	54.97	78.31d-m
Cumbika	63.6	74.43	85.8	79.72	78.47	81	57.05	84.41	84.16	40.55	72.92mno
13.7	78.33	93.57	85.42	84.13	75.08	89.72	83.52	87.71	82.91	39.69	80.01c-k
Sun Red	83.62	89.96	92.55	93.25	89.76	89.3	93.74	89.22	93.58	68.4	88.34a
Innovator	71.96	91.13	84.8	69.02	81.6	-	80.22	89.98	92.55	79.79	82.34a-g
Alverstone Russet	68.96	84.05	89.35	75.47	82.28	91.81	87.1	85.91	75.35	63.63	80.39c-j
Location Mean	66.35	80.51	82.11	78.61	80.17	78.24	74.34	82.29	81.83	41.41	74.61
CV	10.234										

3.3 Dry matter content (%)

The dry matter content of a tuber is a crucial component for a variety's processing quality as well as export potential [19]. It's also a strong predictor of potato storage and maintaining quality [20]. Tuber dry matter content varies widely between cultivars and is a highly genetically determined feature. Tuber dry matter content must be greater than 20% for processing [21, 22]. The dry matter content of the tested varieties is presented in table 3. All the varieties did not behave similar from location to location, which could be attributed to the microclimatic effect of the multiple locations or partially sampling error. The highest average dry matter was found in the Gazipur location (21.56%) and followed by Jashore (20.89%) and Madaripur (20.82) location. This is happened due to the clear sunshine of these region during the potato growing season. Clear sunshine increases the photosynthesis which helps in more carbohydrate accumulation and ultimately increase the dry matter percentage. The result indicates that the location which produces a bigger sizer size tuber has lower dry matter. Ifenkwe, et al. [23] reported that the production of large tubers does not necessarily result in high dry matter content. The highest dry matter was found at BARI Alu-12 (23.88%) followed by BARI Alu-53 (23.79%), BARI Alu-28 (23.07 %), BARI Alu-46 (22.67%), BARI Alu-71 (22.61%), BARI Alu-68 (22.50%), BARI Alu-72 (22.50%) and Innovator (22.68%). Similar results were reported by different scholars on potatoes [24-26].

Table 3. Dry matter (%) of selected potato genotypes as influenced by different environments during 2020-21

Variety\ location	Dry matter (%)							
	Gazipur	Bogura	Rangpur	Madaripur	Thakurgaon	Debiganj	Jashore	Mean
BARI Alu-7 (Diamant)	23.06	18.30	21.61	22.20	22.55	-	22.00	21.62b-g
BARI Alu-8 (Cardinal)	23.41	20.93	21.78	25.60	23.42	20.39	21.50	22.43a-d
BARI Alu-12 (Dheera)	27.47	21.93	22.55	23.85	25.07	20.27	26.00	23.88a
BARI Alu-13 (Granola)	17.40	20.30	16.37	20.25	17.55	22.98	17.50	18.91n-u
BARI Alu-21 (Provento)	21.87	19.80	20.44	20.50	16.95	21.11	21.50	20.31f-n
BARI Alu-25 (Asterix)	21.46	20.05	19.31	20.95	18.92	-	19.00	19.95h-p
BARI Alu-27 (Espirit)	16.99	18.30	19.35	17.45	16.29	16.43	19.50	17.76t-y
BARI Alu-28 (L. Rosetta)	23.72	20.55	23.28	23.60	22.93	21.89	25.50	23.07ab
BARI Alu-29 (Courage)	21.45	20.55	20.84	21.60	20.86	20.56	24.00	21.41c-h
BARI Alu-31 (Sagitta)	21.61	18.43	19.09	18.15	20.26	20.81	21.50	19.98h-p
BARI Alu-32 (Quincy)	19.53	19.82	16.68	17.60	20.03	18.45	18.00	18.59o-v
BARI Alu-34 (Laura)	21.31	18.43	18.75	18.90	20.20	18.58	19.00	19.31j-s
BARI Alu-35	25.58	19.80	21.25	22.75	23.62	20.88	24.00	22.55abc
BARI Alu-36	22.95	20.93	22.57	21.45	20.29	20.77	21.00	21.42c-h
BARI Alu-37	22.53	20.55	20.46	21.15	-	-	20.50	21.04c-i
BARI Alu-40	23.59	20.30	21.63	25.55	20.05	18.80	24.00	21.99b-e
BARI Alu-41	22.84	20.30	23.26	22.15	23.56	19.16	22.50	21.97b-e
BARI Alu-44 (Elgar)	19.17	19.18	19.79	24.25	18.00	19.48	20.00	19.98h-p
BARI Alu-46	25.21	20.18	20.60	23.45	22.27	23.95	23.00	22.67abc
BARI Alu-47	22.40	21.93	21.55	22.45	23.16	18.72	21.00	21.6b-g
BARI Alu-48	24.56	18.05	19.87	21.10	20.52	20.18	21.00	20.75e-j
BARI Alu-49	23.08	18.80	20.20	21.05	20.94	18.32	22.50	20.7e-k
BARI Alu-50 (7.86)	21.65	20.80	18.93	22.05	20.96		20.00	20.73e-k
BARI Alu-51 (Bellarosa)	21.16	19.05	18.57	20.55	18.03	17.55	20.00	19.27j-t
BARI Alu-52 (Labadia)	19.16	20.05	17.15	19.85	16.97	20.33	20.00	19.07l-t
BARI Alu-53 (LB-6)	27.33	20.80	23.07	25.50	23.40	20.94	25.50	23.79a
BARI Alu-54 (Musica)	18.60	20.93	17.35	20.20	17.41	16.69	18.50	18.53p-w
BARI Alu-56	21.88	18.05	21.62	17.80	16.37	19.19	21.50	19.49i-q
BARI Alu-57	23.56	20.05	24.22	19.55	22.75	19.13	23.50	21.82b-f
BARI Alu-58 (ElMundo)	-	19.30	13.47	20.60	19.36	16.57	-	17.86r-y
BARI Alu-59 (Metro)	21.46	19.05	20.74	22.40	21.86	18.33	22.50	20.91d-i
BARI Alu-60 (Vivaldi)	19.19	19.55	15.98	18.30	17.38	16.06	19.00	17.92r-y
BARI Alu-61 (Volumia)	19.92	19.30	16.36	20.20	16.07	15.63	18.50	18q-y
BARI Alu-62 (9.112)	22.24	19.30	19.22	20.45	20.55	16.59	21.00	19.91h-p

Variety\ location	Dry matter (%)							
	Gazipur	Bogura	Rangpur	Madaripur	Thakurgaon	Debiganj	Jashore	Mean
BARI Alu-63 (9.125)	19.61	18.93	18.27	20.95	16.27	18.10	21.00	19.02m-t
BARI Alu-64 (Folva)	21.90	19.80	17.83	19.65	21.78	18.37	21.50	20.12g-o
BARI Alu-66 (Pamela)	20.51	18.80	19.45	20.90	20.94	18.95	20.00	19.94h-p
BARI Alu-68 (Atlantic)	24.33	19.30	22.01	22.40	22.30	21.13	26.00	22.5abc
BARI Alu-71 (Dolly)	24.09	19.80	21.88	24.65	22.31	20.52	25.00	22.61abc
BARI Alu-72 (CIP-139)	23.79	21.55	22.63	20.70	25.00	20.32	23.50	22.5abc
BARI Alu-73 (CIP-127)	23.24	19.80	19.44	22.95	19.44	-	24.00	21.48b-h
BARI Alu-77 (Sarpomira)	22.90	20.30	19.95	21.05	19.74	19.66	20.00	20.51e-m
BARI Alu-78 (CIP-112)	23.97	20.30	20.60	23.45	21.11	18.83	22.50	21.54b-g
BARI Alu-79 (CIP-126)	20.16	19.05	18.24	21.25	18.02	17.55	20.00	19.18k-t
BARI Alu-81 (CIP-10)	26.27	20.30	20.86	20.85	20.39	-	23.00	21.95b-e
BARI Alu-82 (11.68)	21.54	19.30	19.34	23.10	19.93	16.78	20.50	20.07gh-o
BARI Alu-83 (Cimega)	20.34	17.68	15.32	15.85	20.44	-	18.00	17.94q-y
BARI Alu-84 (Memphis)	19.15	18.43	16.56	19.30	17.28	14.57	19.00	17.76t-y
BARI Alu-85 (7 four 7)	17.03	19.05	14.38	17.20	16.13	17.01	18.00	16.97xy
BARI Alu-86 (12.13)	19.11	19.05	12.96	19.90	17.24	15.00	18.00	17.32v-y
BARI Alu-87 (CIP-225)	18.86	20.93	17.47	16.95	18.42	-	18.50	18.52p-x
BARI Alu-88 (CIP-239)	18.02	19.80	18.18	20.75	19.06	-	18.00	18.97m-u
BARI Alu-89 (Fortus)	21.30	19.05	17.63	18.20	16.57	15.03	17.00	17.83s-y
BARI Alu-90 (Alouette)	20.08	20.05	19.04	19.45	17.85	19.29	20.00	19.39i-r
BARI Alu-91 (Carolus)	20.06	19.05	17.39	21.35	17.09	17.02	18.50	18.64o-v
Labela	17.57	17.68	16.98	18.35	15.35	16.76	19.00	17.38u-y
Jarjina	19.17	17.68	14.58	17.20	15.70	16.76	18.00	17.01wxy
Cumbika	15.57	20.68	15.85	19.45	14.48	15.13	20.00	17.31v-y
13.7	22.81	20.30	19.56	21.65	19.90	19.42	22.00	20.81e-j
Sun Red	17.05	19.05	16.71	16.85	15.65	14.07	16.00	16.48y
Innovator	25.60	19.80	24.58	22.40	23.81	17.45	23.00	22.38a-d
Alverstone Russet	23.54	20.05	19.86	20.55	20.34	20.15	19.50	20.57e-l
Location Mean	21.56	19.66	19.28	20.82	19.69	18.62	20.89	20.10
CV	8.56							

4. CONCLUSION

It was discovered that varietal and environmental differences, as well as their interaction, had a significant impact on yield and potato characteristics. The areas of Rangpur, Debiganj, Thakurgaon, and Bogura in Bangladesh could be a prospective place for export potato production through contract farming and the better-performed variety could be selected for export from Bangladesh. These results discovered significant heterogeneity in tuber production and other yield-related variables across the released potato varieties. This indicated a higher likelihood of employing these genotypes in the crossover program to improve tuber production and other relevant agronomic or quality parameters.

REFERENCES

1. Devaux A, Kromann P, Ortiz O. Potatoes for sustainable global food security. Potato Res. 2014; 57:185–199.
2. Amin MN, Rahman MM, Rahman M, Al Mahmud A, Naznin A, Islam MM, Kundu BC, Alsuhaibani AM, Gaber A, Ahmed S. Flowering Behavior and Selection of Hybrid Potato Clones through LXT Breeding Approaches. Agriculture 2022; 12:501. https://doi.org/10.3390/agriculture12040501.
3. Galdón BR, Rodríguez LH, Mesa DR, León HL, Pérez NL, Rodríguez Rodríguez EM, Romero CD. Differentiation of Potato Cultivars Experimentally Cultivated Based on Their Chemical Composition and by Applying Linear Discriminant Analysis. Food Chem. 2012; 133:1241–1248.
4. Gibson S; Kurilich AC. The Nutritional Value of Potatoes and Potato Products in the UK Diet. Nutr. Bull. 2013; 38:389–399.
5. Navarre DA, Pillai SS, Shakya R, Holden MJ. HPLC Profiling of Phenolics in Diverse Potato Genotypes. Food Chem. 2011; 127:34–41.
6. Zarzecka K, Gugala M. The effect of herbicides and soil tillage systems on the content of polyphenols in potato tubers. Pol. J. Environ. Stud. 2011; 20:513–517.
7. Liu RH. Health-Promoting Components of Fruits and Vegetables in the Diet. Adv. Nutr. 2013; 4:384S–392S.
8. FAOSTAT. Food and Agriculture Data; Food and Agricultural Organization of United Nations: Rome, Italy, 2020. Available online:http://www.fao.org/faostat/en/#data/QC (accessed on 15 May 2022).
9. Islam MM, Naznin S, Naznin A, Uddin MN, Amin MN, Rahman MM, Tipu MMH, Alsuhaibani AM, Gaber A, Ahmed S. Dry Matter, Starch Content, Reducing Sugar, Color and Crispiness Are Key Parameters of Potatoes Required for Chip Processing. Horticulturae2022; 8:362. https://doi.org/10.3390/ horticulturae8050362.
10. Roy, Quader, 2015. Keynote Paper on Potato Export Present and Future. Presented on the workshop on Potato Export, Present and Future. Organized by Bangladesh Potao Exporters Association BARC, Dhaka, Bangladesh.
11. Mohammadi J, Khasmakhi-sabet SA, Olfati JA, Dadashpour A, Lamei J, Salehi B. Comparative studies of some new potato cultivars and their morphological characteristics. Biosci. Biotech. Res. Asia 2010; 7:121–126.
12. BARI (Bangladesh Agricultural Research Institute). Developed Crop Varieties of Potato. 2021. Available online: https://baritechnology.org/m/categories/index. (Accessed on 16 May 2022).
13. Kundu BC, Naznin S, Kawochar MA, Islam MM, Al Mahmud A, Amin MN, Uddin MN, Hossain KMD. Selection of Processing Potato Varieties Through Multi -Location Trials. Malaysian Journal of Sustainable Agricultures2022; 6(2):65-71.
14. Ahmmed S, Jahiruddin M, Razia M, Begum RA, Biswas JC, Rahman ASMM, Ali MM, Islam MKMS, Hossain MM, Gani MN. Fertilizer Recommendation Guide; Bangladesh Agricultural Research Council (BARC): Dhaka, Bangladesh, 2018.
15. Sharkar M, Ahmed JU, Ahmed SF, Al Meraj SMZ, Din MMU. Effect of harvesting dates on the yield and tuber quality of processing potatoes. Bangladesh Journal of Agricultural Research 2019; 44(1):179-193.
16. R Core Team. R. A Language and Environment for Statistical Computing; R Foundation for Statistical Computing: Vienna, Austria, 2013; Available online: http://www.R-project.org/ (accessed on 17 May 2022).
17. Tessema L, Mohammed W, Abebe T. Evaluation of potato (Solanum tuberosum L.) varieties for yield and some agronomic traits. Agriculture 2020;5(1):63-74.

18. Amin MN, Rahman MM, Naznin S, Alam MK, Tipu MMH, Prodhan MZH., Islam MM, Kundu BC. Tuber Yield and Stability Assessment of Potato Genotypes in Bangladesh. Indian Journal of Agricultural Research 2021; 55(5):609-613. DOI: 10.18805/IJARe.A-607.
19. Leonel M, Do Carmo EL, Fernandes AM, Soratto RP, Ebúrneo JA, Garcia ÉL, Dos Santos TP. Chemical composition of potato tubers: the effect of cultivars and growth conditions. Journal of food science and technology 2017; 54 (8):2372-8. https://doi.org/10.1007/s13197-017-2677-6.
20. Lisinska G, Leszczynski W. Potato science and technology. Springer Science & Business Media. 1989.
21. Ezekiel R, Verma SC, Sukumaran NP, Shekhawat GS. A guide to potato processors in India. 1999; Technical Bulletin No. 48, CPRl, Shimla, PP. 39.
22. Kellock T. Potatoes: factors affecting dry matter. Agriculture notes. AG0323. Victoria, Australia: State of Victoria, Department of Primary Industries. 1995.
23. Ifenkwe OP, Allen EJ, Wurr DCE. Factors affecting the relationship between tuber size and dry-matter content. American Potato Journal 1974; 51:233–242. https://doi.org/10.1007/BF02851418.
24. Abbas G, Farooq K, Hafiz IA, Husain A. Assessment of processing and nutritional quality of potato genotypes in Pakistan. Pak J Agric Sci. 2011;48(3):169–75.
25. Asefa G, Wassu M, Tesfaye A. Evaluation of Potato (Solanum tuberosum L.) Genotypes for Resistance to Late Blight at Sinana Southeastern Ethiopia. Int J Agric Res Innov Technol. 2016;6(1):21–5.https://doi.org/10.3329/ijarit.v6i1.29208
26. Nasiruddin M, Ali Haydar FM, Rafiul Islam AK. Genetic diversity in potato genotypes grown in Bangladesh. Int Res J Biol Sci. 2017;6(11):1–8.